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(54) Title: LENTICULAR LENS SYSTEM AND METHOD FOR USE IN PRODUCING IMAGES WITH CLEAR-WALLED CONTAINERS

(57) Abstract: A container for producing a graphical image within the container. A container wall is provided with a front portion and a rear portion. A lenticular lens array is provided integral with the front portion of the container wall with a first optic surface, e.g., a plurality of parallel lens or ribs providing lenticules, contiguous with an exterior surface of the container wall and a second optic surface contiguous with an interior surface of the container wall. The array has a focal point on the rear portion of the container wall. A printed image is positioned near the focal point on the rear portion of the container wall to be registered to the lenticules of the array and may be printed directly on the exterior surface on the rear portion of the container wall or printed on a label that is attached to the exterior surface of the container wall.

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## LENTICULAR LENS SYSTEM AND METHOD FOR USE IN PRODUCING IMAGES WITH CLEAR-WALLED CONTAINERS

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           The present invention relates, in general, to optical systems using lenticular lens materials or sheets to produce images, and, more particularly, to a lenticular lens system and method for producing images, such as 3-dimensional, colored images, inside or outside of containers with clear or translucent walls that includes forming at least a portion of the lenticular lens  
10           system integral with one or more of the container walls.

#### Relevant Background

          Clear containers fabricated from plastic and glass are used extensively in packaging of goods ranging from bottled water, alcoholic beverages, and soda pop and other beverages to soap and other household products. Billions  
15           of such containers are produced each year typically using blow mold or injection molding technologies. The packaging industry continually struggles to meet two important and, often competing, goals: producing attention-getting, attractive containers to enhance marketing of the product inside the container and controlling material and production costs of the container.

20           In the competitive packaging and retailing industries (and especially, the beverage industry), marketing professionals and designers struggle to develop the individuality of their product, and most product differentiation is accomplished with the container and its packaging. For example, there is generally little difference between the products of one bottled water company  
25           and another and often little difference between one soda pop and another or between one alcoholic beverage and another. The differences are often ones of perception of the products in the minds of the consumer, and this difference in perception is created by advertising and marketing and, in large part, through creative packaging that leads to product identification by package recognition.  
30           Studies have shown that a large percentage of purchasing decisions are made

at the point of sale when a consumer is faced with numerous products arranged side-by-side and that many of the final purchasing decisions are based at least in part on the attractiveness or distinctiveness of the packaged product or container combined with brand awareness. Hence, a great deal of time, effort, and money is spent on graphics, design, and presentation of the product container such that the product in its container stands out from other similar products on a shelf. For many products, the cost of packaging exceeds the cost of the actual product sold in the container or packaging.

Eye catching graphics in packaging can play a large part at the retail level in making a product appealing to consumers. In the packaging industry, there are a variety of techniques that can provide informational graphics as well as illustrative or "eye appeal" graphics that include one color or use more elaborate multi-color graphics or photographs. More elaborate graphics are often produced with lenticular graphic labels using 3-dimensional (3D) and animation. Lenticular lens material is used in the packaging industry for creating promotional material with appealing graphics and typically involves producing a sheet of lenticular lens material and adhesively attaching the lenticular lens material to a separately produced object for display. The production of lenticular lenses is well known and described in detail in a number of U.S. patents, including U.S. Patent No. 5,967,032 to Bravenec et al. In general, the production process includes selecting segments from visual images to create a desired visual effect and interlacing the segments (i.e., planning the layout of the numerous images). Lenticular lenses or lens sheets are then mapped to the interlaced or planned segments, and the lenticular lenses are fabricated according to this mapping. The lenticular lenses generally include a transparent web that has a flat side or layer and a side with optical ridges and grooves formed by lenticules (i.e., lenses) arranged side-by-side with the lenticules or optical ridges extending parallel to each other the length of the transparent web. To provide the unique visual effects, ink (e.g., four color ink) is applied to or printed directly on the flat side of the transparent web to

form a thin ink layer, which is then viewable through the transparent web of optical ridges.

While these lenticular lens materials provide excellent visual effects, the use of adhesives and other attachment methods has not proven effective in producing high quality, long-lasting, and inexpensive plastic products. Because attaching the lenticular lens material after producing the container is inefficient and relatively expensive, the plastic manufacturing industry is continually searching for methods for attaching the lenticular lens material to plastic cups or containers as part of the cup or container manufacturing process. To date, the plastic manufacturing industry has only had limited success in overcoming the problems associated with using common lenticular lens material as part of standard plastic fabrication processes. The problems arise because plastic fabrication generally includes processes such as injection molding that involve heating raw plastic materials to a relatively high temperature (e.g., 400 to 500° F or hotter) and then injecting the fluid plastic into a mold with the shape of the desired plastic object or by otherwise processing the molten plastic. The ink or ink layer has a chemistry that does not stay intact when the ink is heated to these high temperatures, and the image is destroyed or at least significantly altered.

Further, the use of these graphic techniques is often rejected by the retail industry due to its high cost per container. The lenticular lens labels are typically costly and are difficult to justify based on a cost-benefit analysis, e.g., the additional customer attention and increased sales are typically not offset by the reduced profit on each product sale. The challenge continues to be to create eye-catching graphics or packaging at a very low cost or even with a cost that is similar to packaging already used in present products. Lenticular labels presently provide more desirable effects and graphics than holographic labels as lenticular technology allows the use of accurate color while holographic labels typically require large amounts of light often not available in retail environments and often do not reproduce colors effectively. There is a

direct relationship in lenticular lenses between lens thicknesses and lenticules per inch (LPI) or frequency and the resulting amount and quantity of data and the overall graphic quality and effect achieved by the lenticular labels, which directly affects the labels cost and physical thickness. In other words, creating a desirable graphic is often a balancing act between adding data and increasing thickness of the lens and reducing material costs and label thicknesses. Similarly, a typical cost-cutting technique of container manufacturers is reducing the thickness or overall material used in the container and container walls. Some efforts have been made to utilize thin lens technologies to provide more data and enhanced graphics with less materials and reduced material costs, but the overall graphic effects have been only minimally successful with marginal quality and effectiveness.

Hence, there remains a need for a method and system of using lenticular lens technologies in standard containers to produce enhanced graphic effects to provide improved marketing capabilities for the container and product in the container. Preferably, such a method and system facilitates production of containers at a cost that is comparable to the cost of producing existing containers that do not incorporate lenticular lens technologies with similar material thicknesses and with similar container strengths.

## SUMMARY OF THE INVENTION

The present invention addresses the above problems by providing a lenticular lens systems with a lenticular lens array fabricated as part of the container to be integral with one of the container walls. In other words, the container itself is used to construct a lenticular lens array to focus on a selected portion of the container in which a printed image is positioned. In one embodiment, the lenticular lens array is integrally formed in a front portion of a clear container wall to focus on a rear portion of the container wall with the lenticules on an exterior surface of the container. A label or other image presentation element is attached to the container so as to precisely position a printed image adjacent the rear portion of the container upon which the

lenticular lens assembly is focusing. The lenticular lens assembly can be configured to produce a graphical image from the printed image at a number of locations within the container or, in some cases, outside the container. In one embodiment, the graphical image is displayed so as to appear to be floating  
5 within liquid contents of the container, such as water or other clear or translucent liquid, in the center of the container. The space or distance in the container between the lens array and the rear portion of the container is selected to facilitate focusing a powerful lens on the rear portion to enable a wider or more coarse lens array that has space to carry more data and/or more  
10 images, which creates a greater overall visual effect.

In an important embodiment of the invention, the lenticular lens system includes a lenticular lens array that is formed in a rear portion of a container wall with the lenticules formed on an interior surface of the container wall so as to focus on a printed image on a label (or on the exterior of the container wall)  
15 attached to the container wall. A viewer would look through a clear front portion of the container wall, through the bottle (and its contents), through the lens, and to a focal point directly behind the lens array. This embodiment is useful with glass containers that provide a greater optical gain due to the thicker walls of the container. This arrangement can be thought of as a lens in the container  
20 arrangement that is quite different from prior uses of lenticular sheets that were glued to exterior portions of containers. A lens-in-the-container arrangement is also useful for flexible or collapsible drink containers (such as juice pouches) in which a clear window is provided in a front wall (such as a wall containing a straw hole) and a lens array is provided in the rear wall of the container. The  
25 lens array is mapped to a printed image provided directly behind the lens array on the rear wall. Typically, the walls are metallic and opaque behind the printed image.

The lenticular lens array are configured or designed based on a lens fabrication process that utilizes a number of mathematical relationships of the  
30 lens array and container physical characteristics (such as lenticules per inch,

radius of each lens or lenticule, viewing angle of the lens array, and curvature of the container wall) to create a focal point on the back of the container upon which the interlaced printed image(s) is placed or positioned with the label element. The label or printed image presentation element are attached to the container such that corresponding lenticules in the lens array in the front portion of the container wall are registered or mapped with the interlaces printed images on the label, which typically correspond to the lenticules in frequency. In some embodiments, the printed images are instead printed directly on the rear portion of the container wall (such as on the exterior wall of a glass or plastic bottle or container). The produced or viewed graphical images may be any of a number of images, such as 3D images or animation and effects may include full action video clips to images in full 3D that are floating in the container. The shape of the container walls, such as cylindrical or frustoconical, provide an optical advantage in that the a viewer can see around the produced images, which enhances a produced 3D effect. The cost of manufacturing a container with the lenticular lens system is significantly less than the cost to apply a lenticular lens label or attach a lenticular insert and is often comparable to the cost of producing the container without the added system (i.e., there is no or very little added material costs and relatively low original engineering costs and added manufacturing costs).

In one embodiment, the lenticular lens array is replaced with another useful lens configuration for focusing on the rear portion, such as a fresnal lens array, and in some embodiment, one or more light collection lenses are provided at different locations on the container walls to collect light and focus it on the rear portion and/or printed image to enhance the produced graphical image. Typically, the lenticules in the lens array are positioned to run vertically or parallel to a central axis of the container to provide 3D effects or graphical images. However, in other embodiments, the lenticules may extend horizontally or transverse to the central axis of the container to provide graphical images with movement.

More particularly, a container is provided with a lens system for producing a graphical image visible from the exterior of the container. The container includes a container wall with a front portion and a rear portion separated by a distance (such as the inner diameter of a cylindrical container).  
5 A lenticular lens array is provided integral with the front portion of the container wall with a first optic surface, e.g., a plurality of parallel lens or ribs providing lenticules, contiguous with an exterior surface of the container wall and second optic surface or transparent layer contiguous with an interior surface of the container wall. The lenticular lens array is configured with a focus distance  
10 substantially equivalent to the distance between the front and rear portions or with a focal point on or about the rear portion of the container wall. The container further includes a printed image, such as an interlaced image, positioned near the focal point on the rear portion of the container wall. Typically, the printed image is positioned so as to be registered or mapped to  
15 the lenticules of the array and may be printed directly on the exterior surface on the rear portion of the container wall or printed, such as with mirror printing, on a label which is then attached to the exterior surface of the container wall. In some embodiments, a lens element is also provided in the container wall to collect light striking the lens element and direct it toward the printed image or  
20 focal point.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view of a container, i.e., a bottle for water and the like, showing an image viewable through a lenticular lens array formed in the front portion of the container wall (i.e., as a one-piece unit or integral or contiguous  
25 with the container wall) with the printed image provided on the inside of a label wrapped around the container and placed (or registered) adjacent the rear portion of the container wall;

Fig. 2 is a side view of the container of Fig. 1 showing the image created in the center of the bottle (i.e., "floating" in the container contents) by the



combination of the front lenticular lens array and the rear printed image on the label;

Fig. 3 is sectional view of the container of Fig. 1 looking downward on the wall containers showing the lenticular lens array and the label with a registered printed portion;

Fig. 4 is an enlarged view of part of the sectional view of Fig. 3 illustrating in more detail the lenticular lens array formed integrally with the container wall;

Figs. 5, 6, and 7 are similar to Figures 1-3 and show another embodiment of a container fabricated according to the invention utilizing a lenticular lens array formed integrally with the rear wall of the container adjacent a printed portion of a label installed externally to the container and function in combination to focus an image on the rear wall of the container;

Fig. 8 is side view of another embodiment of a container similar to the container of Figs. 1-4 including a lenticular lens system that further includes a light collecting lens in an upper portion of the container wall configured for focusing light on the printed side of the label element adjacent the rear wall of the container;

Fig. 9 is yet another embodiment of a container, such as a glass bottle, with a lenticular lens system that includes a front lens array and a printed image integral to the rear container wall (e.g., printed on the external portion of the container rear wall or formed within the wall itself during fabrication);

Figs. 10 and 11 are graphs illustrating, for two exemplary viewing angle and lens radius combinations in a lenticular lens array, a relationship between lenticule frequency as measured in lenticules per inch and the lens coefficient as calculated by a process of the invention used in fabricating lenticular lens systems and as measured in fabricated lens systems;

Fig. 12 shows a sectional view similar to Fig. 3 that is enlarged and simplified (e.g., with significantly reduced lenticule frequency) to more clearly

shown the use of exterior lenses to achieve effective image coverage in curved containers;

Fig. 13 shows a sectional view similar to Fig. 12 of an inside-the-container embodiment in which the lenticules of the lens array are positioned  
5 inside the container to focus on a printed image positioned on an external surface of the wall of the container or printed directly on the exterior surface;

Fig. 14 illustrates yet another lenticular lens system in a container (such as a clear glass bottle, e.g., a beer bottle and the like) in which the lenticules of the lens array are positioned inside the container, a light focusing lens is  
10 provided to direct light toward the lenticules and/or the printed image behind the lenticules, and an additional printed image is provided on the front portion of the container to provide forefront images or objects to enhance the 3D or other image effects obtained by the lens system; and

Fig. 15 illustrates a flexible beverage container (such as common juice  
15 pouches or bags) with a partial cutaway to show that a lenticular lens system is provided in the container that provides a clear front window to allow light into the container and to provide a line of sight to a lens array with lenticules positioned inside the container with a printed image provided on the inside or interior wall of the container (typically, fabricated from a metallic material).

## 20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figures 1 and 2 illustrate a container 100 utilizing a lenticular lens system of the present invention to produce a floating 3D image 140. As shown, the container 100 is provided with a standard shape utilized for typical plastic bottles used for distributing water or other beverages. As such the container  
25 100 includes a clear or translucent container wall 110 having a substantially cylindrical shape for containing liquid 104. The container wall 110 is typically formed of glass or more typically of a plastic such as polyvinyl chloride (PVC), polypropylene, polyethylene, polyester (such as PET, APET, PETG, and the like) or other plastic used by the packaging or container industry. The container  
30 100 may be formed by blow molding, injection molding, or any other technique

useful for producing containers and adapted (as necessary) for the glass or plastic material used to fabricate the container 100.

According to an important aspect of the invention, a lenticular lens array 120 is provided in a front portion of the container wall 110. The lenticular lens array 120 is formed integral with the container wall 110, typically in the same molding or other fabrication process and of the same material. The lenticular lens array 120 is configured with numerous lenticules or lenses formed by ridges or ribs that extend parallel to each other and to a longitudinal axis of the container 100. The lenticules of the lens array 120 are configured in frequency (lenticules per inch) and shape (such as width and radius) based on the material of the container wall 110 (and array 120), based on the liquid contents 104 of the container 100, and the curvature of the container wall 110 to focus on the rear portion of the container wall 110. The space or distance (i.e., the inner diameter of the container) allows a coarser configuration for lens array 120 to be used while still providing a large quantity of data in the printed image 132. The lenticular lens array 120 can have a wide variety of dimensions (such as a height and "width") selected based on the size of the container 100 and the size of the printed image 132 and shapes (such as a square, a rectangular, a triangle, a circle, an oval, or any other useful shape for viewing the image 132).

With the lenticular lens array 120 focusing on the rear portion of the container wall 110, a graphical image 140 can be produced within the container so as to "float" in the liquid 104 or elsewhere by providing a printed image 132 at the focal point. In this regard, a label or printed image presentation element 130 is provided with a printed image 132 on the inner surface of the label 130, i.e., the portion abutting the rear portion of the container wall 110, which is shown in Figure 2. The label 130 is shown to be wrapped around the container wall 110 so as to cover the lens array 120 and the rear portion of the container wall 110. The label 130 fabricated from a clear material such as plastic so as not to interfere or block light from passing through the lens array 120, which

allows a viewer 150 to see as shown by a sight line 152 the graphical image 140 which is produced by the lens array 120 and the printed image 132.

The label 130 includes a data area or backdrop portion 134 in which a printed image 132 is provided, and in some embodiments, the data area 134 includes additional images, such as text, for viewing or may provide a background color(s) useful for emphasizing or highlighting the printed image 132. The printed image 132 is positioned relative to the rear portion of the container (i.e., the focal point of the lenticular lens array 120) to map or register the interlaced printed image 132 with corresponding lenticules or portions of the lenticular lens array 120 to effectively produce the graphical image 140 to the viewer 150. The image 132 may be printed using known techniques for printing images or data to achieve graphics such as 3D, animation, or action and for use with lenticular lenses or lenticular materials but the invention is not limited to a specific technique. For example, the image 132 may be printed upon the interior or reverse side of label 130 via web or offset press operations to form an ink layer with corresponding interlaced images in conjunction with the appropriate mathematics of the lens materials and configuration of array 120. The mathematics preferably not only matches the lens materials but also the distortion caused by the curvature of the container wall 110 and integral array 120 and of the liquid 104 in the container 100. In the case of a bottle or other conical shaped container 100, the lens or lenticules of the array 120 "open up" and create a new mathematical pitch. This pitch is predetermined before the labels 130 and plates are made and printing occurs so that the printing can be performed with more accuracy and to facilitate registering the label 130 and printed image 132 with the lenticular lens array 120.

Figure 3 shows a sectional view of the container 100. As shown, the lenticular lens array 120 is integral with the container wall 110 with vertically extending lenticules forming a rough exterior surface at the front portion of the container wall 110. Generally, the lenticular lens array 120 has the same overall thickness as the wall 110 and is configured to have a focal point

substantially coinciding with the rear portion of the container wall 110 adjacent the printed image 132 of the label 130. The label 130 is shown to wrap around the entire periphery of the container wall 110 as is common practice in the beverage industry (such as in the bottled water industry), but in some  
5       embodiments (not shown), the label 130 may extend for only a portion of the periphery of the container wall 110 as long as the printed image 132 is positioned adjacent an exterior surface of the rear portion of the container wall 110 that coincides with the focal point (or points) of the lenticular lens array 120.

10           The fabrication of standard lenticular material sheets, i.e., those not formed as part of a container wall 110, is well known by those skilled in the printing arts and such knowledge may be utilized at least in part in designing the molding or arrangement of the lenticular lens array 120 (in combination with the use of the design formulas discussed with reference to Figures 10-13). For  
15       example, lenticular material fabrication is described in U.S. Patent No. 5,967,032 to Bravenec et al. and U.S. Patent No. 5,753,344 to Jacobsen, which are incorporated herein by reference. Additionally, the method of laying out or arranging inserts (or labels 130) for a conical container similar in some ways to container 100 is illustrated in Figure 1 of U.S. Patent No. 5,908,590 to  
20       Yoshimi et al., which is incorporated herein by reference, which is directed to producing labels for foamed resin containers.

Figure 4 illustrates a portion of the cross-section of the lenticular lens array 120 and label 130 shown in Figure 3. As shown, the label 130 is wrapped about the container wall 110 so as to contact the ridged outer surface of the  
25       lenticular lens array 120. Typically, the label 130 is fabricated from a very thin sheet of clear plastic to minimize distortion through the array 120. The lenticular lens array 120 includes a plurality of optical ridges or lenses 122 (extending vertically as shown or horizontally) and a transparent lens layer or web 124. The fabrication and/or design of the lenticular lens array 120 is  
30       discussed in detail (including using mathematical formulas of the invention in

the design processes) with reference to Figures 10 and 11, and for now, it is adequate to understand that the array 120 has an overall thickness,  $t_b$ , that affects focusing of the array 120 and typically is substantially equivalent to a thickness of the container wall 110 (although in some cases the array 120 may be slightly thicker or thinner to provide a desired optical effect and/or provide a desired structural strength). Optical results of the array 120 are also determined by other physical characteristics of the array 120 including the material of the array 120, the frequency of the lenticules or ridges 122 (typically measured in lenticules per inch (LPI)), the curvature of the array 120 as determined by the curvature,  $R_E$ , of the container wall 110, and the radius (or width) of the lenticules or lens,  $R_C$ , and the relationships between these characteristics or design parameters. Additionally, the resulting optical effect is determined in part by the liquid 104 (or lack of liquid) in the container 100 and the distance from the lens array 120 to the rear portion of the container wall 110 (and the printed image) which is approximately the inner diameter of the container 100 at the location of the array 120 and the printed image 132.

Figures 5-7 illustrate another container including another lenticular lens system of the invention, i.e., a system in which the lenticular lenses are provided integral with a portion of a container wall that is printed with data or a printed image (interfaced image) or abuts a label or presentation element having such data or printed image. As shown, the container 500, e.g., a plastic water or soda bottle, a soap or other similar container, or a glass bottle, jar, and the like, includes a container wall 510. A lenticular lens array 520 is formed integral to a rear portion of the container wall 510 and includes a plurality of lenticules or ridges on an inward facing side 524 and a flat layer 522 facing the exterior portion of the container 500. The lenticule surface 524 is configured to focus on the flat surface 522 (or the interface between the flat surface or layer 522 and the abutting label or presentation element 530). The label 530 is wrapped around or attached to the exterior surface of the container wall 510 so as to at least partially cover the lenticular lens array 520 and more importantly, to map or register a printed image 534 to the lenticules of the array 520 so as to

create graphical image 540 as viewed through the front portion of the container wall 510. The mathematics used in configuring the lenticular lens array 520 are similar to that used in creating flat lenticular material or sheets with compensation for the curvature of the container wall 510 and integral lenticular lens array 520 (note, however, this is a closing or pinching of the lenticular surface 522 rather than an opening as experienced with the lenticular lens array 120 of Figure 1). The specific location of the array 520 is not limiting to the invention as long as the printed image 534 is placed behind it on or adjacent a corresponding container wall 510 location. Similarly, the size and shape of the array 520 (as well as the orientation of the lenticles) can be varied widely to practice the invention with the array 520 typically being selected to have a size and shape that is larger than or the same size as the printed image 534.

Figure 8 illustrates another embodiment of a lenticular lens system that is useful for enhancing the clarity and effectiveness of the created graphical image. The illustrated container 800 includes a lenticular lens system similar to that used in container 100 of Figure 1 with a lenticular lens array 820 in a front portion of a container wall 810 containing water or other liquid 804 and a label or presentation element 830 with a background or data area 834 with a printed image (interface printing layer) 832 abutting the exterior of the rear portion of the container wall 810. The system of the container 800 is enhanced by the addition of a light collection lens (such as a fresnel lens or other useful lens configuration) 850 which is formed integrally with the container wall 810 at a location or position useful for collecting light and directing or focusing the collected light 820 onto the rear portion of the container wall 810 and more preferably on the portion of the container wall 810 abutting the data area 834 and even more preferably on the portion of the container wall 810 abutting or adjacent the printed image 832. In this manner, the graphical image 820 produced for viewing by the viewer 830 along line of sight 832 is typically more vivid with better color reproduction and image or effect clarity.

Figure 9 illustrates a container 900 in which a label is not utilized but instead data and/or interlaced images are printed directly on an exterior surface (or within) a container wall. Such a container 900 may be fabricated from plastic or glass (such as a liquor bottle for distributing vodka and other alcoholic beverages that are relatively clear or translucent). As shown, the container 900 includes a frontal lenticular lens array 920 with lenticles facing outward or forming an external surface and focusing on a rear portion of the container wall 910 having a data portion with a interlaced printed image 934 (which is typically, but not necessarily, printed on the external surface of the container wall 910). As a result of light (shown by lines 950 and 952), the array 920, and the printed image 934, a viewer 940 is able to see the graphical image 930, which in this embodiment is shown to be displayed or created in the middle of the container 900 to be "floating" in the container 900.

As stated earlier, the method of fabricating the containers with lenticular lens systems can be any of a number of molding or other techniques known within the container or packaging industry. Preferably, however, the lenticular lens array is fabricated to focus on the rear portion of the container (adjacent a printed image on the wall or on a label registered to the lenticles of the array), and such focusing depends on the interactions of a number of array characteristics or design parameters, on the container itself, and the contents of the container. Further, there is a relatively wide arrangement of container designs with differing wall thicknesses, materials, and inner diameters. For example, the wall thickness of the container can exceed 100 mils in some glass containers or be less than 10 mils in many disposable containers, such as PET or other plastic containers used for water, soap, and other products. However, to control costs and maintain strengths, it is typically desirable to match the thickness of the lens,  $t_B$ , to the container wall 110, while the other array 120 parameters can be varied to provide a desired result once a thickness,  $t_B$ , container size and curvature, and material are known and the design process of the invention provides a method of determining useful values for the array 120 characteristic or design parameters. In this regard, the following discussion



along with reference to Figures 10 and 11 provides a description of how fabrication and design of a lenticular lens array for a system and container of the invention can be performed efficiently and accurately through the use of the disclosed mathematical formulas and processes.

5 Referring first to Figure 4, there is a direct relationship between the lenticule lens array thickness (or container wall thickness),  $t_B$ , the lenticule frequency (e.g., LPI), and both the amount and quality of data and the overall graphic quality and effect provided by the lenticular lens system. In general, as lens thickness increases,  $t_B$ , the size of the lenticule (as indicated by the width  
10 or radius,  $R_C$ , of the lens ridge 122) gets larger. Hence, the thicker the lenticule ridge 122 the more data that can be placed under the lenticule 122 on the printed image 132 and the better overall 3D, animated, or other effect can be achieved in graphical image 140. According to one aspect of the invention, a mathematical or formulaic process is used to create or design the lenticular  
15 lens array 120 and is adapted such that the lens thickness,  $t_B$ , lenticule frequency (LPI), radius,  $R_C$ , and other array and system parameters such as viewing angle and array/container curvature work in unison to create a desired lens, with selected parameters being set to obtain a desired result (such as better 3D effects or better animation) and then adjusting other parameters to  
20 support the preset characteristics (such as curvature, liquid optical properties, material of the container, and size of the container for separation between the lens array 120 and the rear portion of the container wall 110). Significantly, by placing the lenticular lens array 120 on the front portion of the container wall 110 and the interlaced printed image 132 on the rear portion of the container  
25 wall 110, the thickness of the lens,  $t_B$ , can be significantly reduced due to the increased focal length (i.e., container inner diameter) while still obtaining more effective 3D, animation, and other higher data effects than similar sized lenticular material in which the image is adjacent the lenticules 122 and web 124.

In general, it is desirable to minimize the use of excess materials for the lens array 120 in most plastic container applications. To provide a desirable or effective graphic effect in these applications, it is desirable to use the most effective or powerful lenticular lens array configuration as possible with a given container wall thickness. In practice, such lens arrays generally have viewing angles of 45 degrees or more and more radical lens radii,  $R_C$ , of 4 to 8 degrees. Many popular and functional lens array configurations that can be used for array 120 that are good for 3D and animation have viewing angles in the 47 to 50 degree range with lens radii in the 4 to 6 degree range, and many manufactured lenticular materials have viewing angles of about 48 degrees with 5 degree lens radii, which are readily manufactured and are compatible for existing printing technologies. These ranges are provided for exemplary purposes and not as a limitation as these parameters may readily be altered to practice the invention as long as the parameters of the array discussed below are selected to substantially comply with the following mathematical relationships and dependencies.

In the past, lenticular lens design has involved a relatively large amount of guesswork with success depending on a designer or manufacturers prior experience and knowledge. The design problem is compounded for the lens arrays (such as array 120) included in container walls as the arrays are made of a number of materials that must be calibrated or matched to the curve or shape of the container wall (and integral array). In practice, the thickness of the container wall (and hence of the lens,  $t_B$ ) is known or set and the material of the lens array and container wall is preselected, which provides a known refractive index for the lens array. The refractive index of a material relates to the rate at which the material can bend white light, with the higher the index the less thickness is required to bend the light (which is desirable in most container applications to control material costs). While numerous materials may be utilized to fabricate containers, most plastic containers are made of PET, which has a similar refractive index to APET and PETG, and hence, the following examples employ PET as the container wall and lens array material.

The following symbols are used: "A" for the refractive index of the polymer or the glass of the container wall and lenticular lens array; "B" for the thickness of the lens array (i.e.,  $t_B$ ); "C" for the radius of the top of an individual lens (i.e.,  $R_C$ ); "D" for the viewing angle of the array; "E" for the curvature of the container (i.e.,  $R_E$ ); "F" for the frequency of the lenticules typically provided in units of LPI; and "G" for the lens coefficient (which was determined by inventors to be the ratio of  $F/B$ ). Also, in the following example, parameters or design variables A, C, D, and E are presumed constant and known. The established goal for these design examples are to calculate or determine a working lens frequency for a PET container that has a viewing angle, D, of about 48 degrees, a 4 to 6 degree radius, C, and a thickness, B, of 10.4 mils (e.g., a common container thickness).

In order to determine a useful lenticule frequency, F, a "lens coefficient", G, is calculated to determine the mathematical relationship between existing lens arrays in the marketplace that perform well in lenticular printing applications. In theory, there should be a close or nearly exact mathematical relationship between a calculated or designed lens array and an actual lens array that when graphed would present itself as nearly a straight line or median in which the thickness of the lens, B, required in the lens material at a particular frequency, F, could be determined and/or more importantly, the frequency, F, could be determined that would be necessary to complete a lens array within the restraints of a given or existing container wall thickness and design.

The coefficient, G, is provided by the ratio of  $F/B$  (or G multiplied by B equals F). If the thickness, B, is 10.4 mils and G can be determined to be 11.53 from working or existing lens arrays with about the desired viewing angles, D, and lens radius, C. Hence, in this example, the lenticule frequency, F, is 120 LPI (i.e., 11.53 multiplied by 10.4). In this example, G is obtained from the graph 1000 shown in Figure 10 which shows the graphing of the relationship of frequency, F, to lens coefficient, G, as determined from an actual relationship in a fabricated lens array as shown by curve 1010 from which a

straight line relationship of the lens coefficient, G, is obtained with median line 1020. The graph 1000 is based on a known or existing lens array with a viewing angle of 48 degrees and a 4 to 6 degree lens radius, C, along with a constant refractive index for the material of the lens array, A, and a known curvature of the container, E. The actual curve 1010 was prepared based on the measurements of frequency, F, of 60, 75, 85, 100, 140, and 200 LPI with corresponding thicknesses, B, of 28.5, 18.3, 14, 12, 8, and 6 mils, which led to lens coefficients, G, as graphed of 2.1, 4.09, 5.66, 8.33, 17.50, and 33.30.

Figure 11 illustrates a similar graph 1100 showing the relationship between the lenticule frequency, F, and the lens coefficient, G. A determination of the relationship between lenticule frequency, F, and lens coefficient, G, as measured in a fabricated lens array configured to have of the a viewing angle, D, of 34 degrees and a lens radius, C, of 4 degrees with a fixed refractive index (for PET), A, and fixed curvature of the container and lens array, E, is shown by line 1120. A median line 1110 is then provided or determined for use in later verifications of the calculated or formula derived values of lenticule frequency. The examples provided in Figures 10 and 11 illustrate that for a particular container configuration a lens array can be configured to have an effective lens frequency, F, to achieve desirable results as a number of design parameters are set by the container (such as lens array thickness, B, the refractive index of the container wall and array material, A, and the curvature of the container, E), others can be selected with readily predicted and useful results (such as lens radius, C, and viewing angle, D, combinations), which allows determination of the lenticule frequency, F, based on a known thickness, B, and a known or determinable lens coefficient, G, that is directly related to the frequency, F.

Figure 12 provides an enlarged cross-sectional view of a container 1200 with an optical system of the invention. As shown, a lenticular lens array 1220 is provided integral with a front portion of the container wall 1210. The lens array 1220 is positioned with lenticules 1222 on an exterior surface of the container 1200 and a "flat" lens layer 1224 positioned on an interior surface of

the container 1200. A printed image, such as an interlaced image, 1232 is positioned on an exterior surface of a rear portion of the container wall 1210. The printed image 1232 is mapped to the lenticules 1222 such that particular portions of the data in the image 1232 are matched to one or more of the lenticules or optical ridges 1222. The printed image 1232 may be printed directly on the container wall 1210 or positioned against the exterior surface of the container wall 1210 as part of label attached with adhesives, such as for a label that only covers a portion of the container circumference (such as on soap containers and beer or liquor bottles), or with standard wraparound labeling techniques, such as used with labels that extend about an entire container circumference (such as with bottled water containers).

The lenticules 1222 are shown significantly larger than would be used in practice and at a much lower frequency for to simplify illustration of the effects of container and lens array physical characteristics on the optical effect created by the optical system. A typical embodiment can include lenticules 1222 at a frequency of about 5 to 10 LPI or more with almost a flat lens having a relatively narrow viewing angle, but the specific embodiment may vary based on a number of parameters (such as radius of the container, thickness of the lens 1222, thickness of the container wall 1210, and other physical features). For example, with greater angles of curvature of the exterior surface of the container wall 1210, the mass or thickness of the lenticular lens array 1220 (i.e., thicknesses of lens layer 1224 and lens ridges 1222) may be decreased to achieve a particular graphic result. This results because as the radius is increased in smaller circumference containers 1200 each lens 1222 is not focusing on a flat surface but instead on a convex or inwardly curved surface (i.e., the interior surface of the rear portion of the container wall 1210 adjacent the printed image 1232) as shown by the print width,  $P_w$ . The print width,  $P_w$ , is increased on the container wall 1210 due to the convex interior surface that expands the surface area of the general focus of each lenticule 1222, which, in essence, allows a lenticule 1222 to focus more easily over a greater distance

(the inner diameter of the container 1200) due to the curvature of the container wall 1210.

Overall, the lenticule frequency or LPI and the lens radius can be decreased as the radius of the container 1200 is decreased (or angle of curvature is increased). Likewise, as the radius of the container 1200 increases (i.e., the distance between the lens array 1220 and the printed image 1232 increases) the lenses 1222 may be more flattened (with smaller lens radii) but still provide effective focusing on the printed image 1232 due to the space (i.e., as measured approximately by the inner diameter of the container 1200). The inner space of the container when combined with the container curvature make it possible to employ a relatively thin, course lens array 1220 to obtain a desired effect. For example, this type of array 1220 can be used to obtain 3D colored patterns.

In one preferred embodiment, the printed image 1232 (and other printed images shown in other figures) can include a first and a second interlaced image. In this embodiment, the lenticular lens array 1220 is mapped to the printed image 1232 such that the first interlaced image is visible when the container 1200 is full of a particular liquid (such as beer, soda, soap, water, and the other translucent or clear liquids) and the second interlaced is visible when the container 1200 is empty (or only filled with air). Such a configuration is obtainable by accounting for the effect of the container contents on light (e.g., the index of refraction and other characteristics of the contents and the distance the light must travel through the contents as measured approximately by the inner diameter of the container 1200). Such a two-image embodiment is useful for facilitating contests in which an initial decorative image is provided by the first interlaced image (or advertises the contest) and an after-use image is provided by the second interlaced image indicating winning and losing containers 1200 (such as with "Try Again" or "WINNER" text or other text and/or images).

Figure 13 illustrates a cross section of container 1300 with inside-the-container embodiment of a lenticular lens system (again enlarged with a significantly reduced lenticule frequency than typically would be implemented in practice for ease of illustration of the concepts of the invention). As shown, a lens array 1320 is provided integral with a rear portion of the container wall 1310 with a lenticular surface of optical ridges 1322 positioned contiguous with the interior surface of the container wall 1320. A printed image 1332 is provided, such as with a label (not shown) or with direct printing, on the exterior surface of the container wall 1310 adjacent to and mapped to the lenticules 1322. The curvature of the lens array 1320 (and corresponding container wall 1310) results in each of the lenticules 1322 focusing on the printed image 1332 with a print width,  $P_w$ , that is larger than would be achieved with a flat lenticular lens sheet.

As with container 1200, the lenticule frequency can be decreased and/or the thickness of the lens array 1320 decreased for containers 1300 with smaller radii (or with lens arrays with greater angles of curvature) but to a lesser degree than container 1200. More importantly, because there is no distance between the lens array 1320 and the printed image 1332, a more direct and known relationship exists between the design or characteristics of the lens array 1320 and a resulting graphic effect. For example, as the curvature of the lens array 1320 increases (inverse relationship to the radius of the container wall 1310), the thickness of the lens array 1320 (or container wall 1310 in embodiments where these thicknesses are approximately equivalent) required for a particular graphical effect is reduced and/or the lenticular frequency can be reduced.

In either of the embodiments shown in Figure 12 and 13, it is often useful to adjust label printing or print image pitch or frequency to obtain a desired graphical effect and/or mapping of interlaced image to lenticules in the arrays 1220, 1320. In practice, the printing pitch provided in the printed image 1232, 1332 is adjusted whether provided on an inner surface of a label or whether printed directly on an exterior surface of the container wall 1210, 1310,

and such an adjustment during container manufacture has not been performed prior to the use of the lenticular lens systems described herein. The printing pitch adjustments are performed differently for the two configurations of Figures 12 and 13. In the exterior lens arrangement of container 1200, as the curvature  
5 of the lens array 1220 is increased (such as due to a decreasing radius of container wall 1210) the print width,  $P_w$ , is decreased or shrunk to match the lenticule placement and shape (assuming a constant lenticule frequency). In contrast, in the interior lens arrangement of container 1300, as the container radius gets smaller and the lens array 1320 gets a greater curvature, the  
10 printing width,  $P_w$ , is increased or made wider to better fill each lenticule 1322 focusing on the printed image 1332.

The effect of contents, such as water or other liquids, will be different in each container 1200, 1300 and should be considered in designing the lenticular lens system for each container 1200, 1300. In container 1200, the addition of a  
15 liquid results in a magnification, e.g., a magnification of 1.5 to 3.0 or more for typical containers, that varies with the properties of the liquid and the container size. Hence, the printed image 1232 preferably is engineered for the expected magnification to obtain a desired graphical effect by ensuring the data strips of the printed image 1232 line up or are mapped to the lens ridges 1222 with  
20 proper dimensions, which is especially important in embodiments of the printed image 1232 which contain a first and a second interlaced image with the first image visible in the presence of the magnification and the second image exclusively visible in the absences of such magnification. In container 1300, the addition of the liquid magnifies the image in a one-way fashion from the rear  
25 portion of the container wall 1310 to the front portion of the container wall 1310. The magnification effect is lessened but still needs to be taken into account in engineering the printed image 1332 to obtain a desired effect. In the container 1300, the created graphical image will basically be the same in the presence and absence of the liquid but will be magnified or enlarged in the presence of  
30 the liquid. Hence, in some embodiments, the printed image 1332 is configured such that the created graphical image is sized based on the front portion of the



container wall 1310. For example, in some embodiments, the printed image 1332 is configured to fill all or some portion of the front portion of the container wall 1310 with a graphical image or effect when the container 1300 is filled with liquid and magnification is taking place and to fill a reduced portion of the front portion of the container wall 1310 when the liquid is removed from the container 1300.

The number of specific arrangements of containers with lenticular lens systems having features of the invention (such as a lenticular lens array integral with a container wall) are expected to be very large and readily apparent to those skilled in the art who have read and understood the description of the invention and these numerous arrangements are believed to be within the scope of the invention. Figures 14 and 15 provide two more exemplary embodiments of containers with lens systems of the invention.

In Figure 14, a container 1400 such as a glass or plastic beer or other beverage bottle is shown with a container wall 1410 retaining liquid 1404. A printed image 1430 is provided on the exterior surface of a rear portion of the container wall 1410. As shown, a lens array 1420 is provided on the interior surface of the rear portion of the container wall 1410 adjacent the printed image 1430. In the container 1400, the lens array 1420 has a thickness greater than the adjacent container wall 1410. In some embodiments of the lens systems or containers of the invention, the lenticules or optical ridges are fabricated or molded by providing additional material at the location of the lens array 1420. For example, the "flat" lens layer of the lens array 1420 may have a thickness substantially equivalent to the container wall 1410 and the additional material may be provided for the lenses such that the thickness of the lens array is the container wall thickness plus the thickness or radius of the optical ridges.

The lens system of container 1400 further includes a light-collecting lens 1450 for collecting and/or directing light rays 1408 toward the lenticular lens array 1420 and/or the printed image 1430. A "floating" graphical image 1438 is produced with 3D effects produced by the combination of the lens array 1420,

the printed image 1430 and collecting lens 1450. To enhance the 3D or graphical effect achieved, the lens system of container 1400 includes a frontal image element 1434 (such as a label or printing directly on the container wall 1410) on the exterior surface of a front portion of the container wall 1410. The frontal image element 1434 includes forefront images 1436 and a transparent portion 1435 (in embodiments of direct printing the transparent portion can be eliminated). The forefront images 1436 enhance the 3D effect by providing images viewable at the outer surface of the container wall 14210 that when combined with the projected 3D image 1438 and the background images on the printed image 1430 produce a multi-layered graphical effect.

Figure 15 illustrates another useful container 1500 in which a lens system of the invention can be incorporated to produce an image to a viewer 1540, such as an image with 3D and motion like a soccer player kicking a ball 1538 that moves through the container 1500 toward the viewer 1540. The container 1500 may be a flexible beverage container, such as those used for distributing juice beverages, with flexible or compressible container walls 1510 that are typically metallic and opaque. A clear window 1535 (such as a transparent or translucent plastic element) is provided in a front portion of wall 1510 to allow light to enter the container 1500 and provide a line of sight to the viewer 1540. The cutaway view shows that the lens system includes a printed image 1530 provided on the interior surface of the rear portion of the container wall 1510. Adjacent to and mapped to the printed image 1520 is a lenticular lens array 1520. In this embodiment, as opposed to those described in Figures 1-14, additional (and often differing) material is provided and attached to the wall 1510 rather than being provided integrally with the container wall 1510. Because the container walls 1510 are not blow or injection molded typically the temperatures occurring during manufacture are low enough to not be a concern in damaging the ink in the printed image 1520 or in damaging the lenticles in the lens array 1520, which can be attached with standard adhesives and practices.

Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed.

For example, the lenticular lens or optical systems of the invention may be incorporated in nearly any container having one or more clear or translucent walls such as containers having substantially rectangular cross-sections or frustoconical shapes and is not limited to bottles, which were provided as exemplary and useful embodiments in the figures. Further, the design process for selecting the lenticule frequency based on the container wall thickness and other factors is not a required feature of the invention and the lenticular lens systems of the invention may be engineered and design parameters selected using other techniques including experience and knowledge combined with empirical data including trial and error methods involving fabricating sets of prototypes to determine a desired mix of the lenticular lens array design characteristics for a particular container, container wall material, and even for particular liquids.

## CLAIMS

## WE CLAIM:

1. A container adapted for producing a graphical image observable by a viewer external to the container, comprising:
  - 5 a container wall having a front portion and a rear portion separated by a distance, the container wall defining an interior space for receiving a volume of a liquid;
    - a lenticular lens array integral with the front portion of the container wall including a first optic surface distal to the interior space comprising a plurality of lenses and a second substantially planar optic surface proximal to  
10 the interior space, wherein the lenticular lens array has a focal point on or about the rear portion of the container wall; and
    - a printed image proximal to the focal point.
2. The container of claim 1, wherein the printed image is an  
15 interlaced image printed on an exterior surface of the rear portion of the container wall.
3. The container of claim 1, wherein the container includes a label with an inner surface contacting an exterior surface of the rear portion of the container and wherein the printed image is an interlaced image printed on the  
20 inner surface of the label.
4. The container of claim 1, wherein the printed image is an interlaced image positioned in the container to register portions of the interlaced image to corresponding ones of the lenses.
5. The container of claim 1, wherein the lenticular lens array is  
25 configured based on the distance between the front and the rear portions to obtain the focal point.

6. The container of claim 1, wherein the container wall has a thickness and the lenticular lens array has a thickness substantially equivalent to the container wall thickness.

7. The container of claim 6, wherein a frequency of the lenses is selected based on the lenticular lens array thickness and a predetermined lens coefficient.

8. The container of claim 1, further including a light collecting element on the container wall receiving light and directing the received light toward an inner surface of the rear portion of the container wall.

9. The container of claim 8, wherein the light-collecting element comprises a fresnel lens.

10. The container of claim 1, wherein the container wall and the lenticular lens array are fabricated from glass or plastic.

11. The container of claim 1, wherein the plastic is selected from the group consisting of PVC, PET, APET, polyethylene, and polypropylene.

12. A method of fabricating a container adapted for producing graphical images, comprising:

forming a container wall having an interior surface defining an interior void for receiving a volume of liquid, the container wall comprising a material through which at least a portion of light striking an exterior surface of the container wall can pass;

providing a lens array integral to the container wall for focusing a line of sight of a viewer on a focus area; and

providing a printed image on or near the focus area.

13. The method of claim 12, wherein the providing of the lens array includes forming the lens array concurrently with the forming of the container wall.

14. The method of claim 12, wherein the lens array includes a lenticular surface contiguous with the exterior surface of the container wall comprising a plurality of optic ribs and a web layer contiguous with the interior surface of container wall, and further wherein the lens array is provided in a front portion of the container wall and the focus area is on or about a rear portion of the container wall.

15. The method of claim 14, wherein the printed image providing includes printing an interlaced image on the exterior surface of the rear portion of the container such that portions of the interlaced image are registered with corresponding ones of the optic ribs.

16. The method of claim 14, wherein the printed image providing includes attaching a label element to the exterior surface of the container wall, the label element including the printed image in a data area and the attaching including mapping the printed image to the focus area to register portions of the printed image to the optic ribs.

17. The method of claim 16, further including prior to attaching, mirror printing the printed image in the data area of the label element as an interlaced image.

18. The method of claim 12, wherein the lens array providing includes concurrently forming the lens array with the forming of the container wall and wherein the lens array includes a lenticular surface contiguous with the interior surface of the container wall and a web layer contiguous with the exterior surface of the container wall, and further wherein the printed image abuts the web layer.

19. The method of claim 12, further including forming a light collecting element integral to the container wall, the light collecting element being adapted and positioned relative to the focus area for receiving a portion

of the light striking the exterior surface of the container and directing the received portion toward the focus area.

20. The method of claim 12, wherein the container wall has a thickness and the lens array includes lenticules at a lenticule frequency, and  
5 further including prior to the lens array providing, determining the lenticule frequency based on the container wall thickness.

21. The method of claim 12, wherein the lens array includes a plurality of lenticules and wherein the printed image providing includes selecting a printing pitch of data on the printed image to match the lenticules.

10 22. The method of claim 21, wherein the printing pitch selecting is performed based on a radius of the container wall and based on a location of the lenticules on either an interior surface of the container wall adjacent the printed image or an exterior surface of the container wall at a location on the container wall distal to the printed image.

15 23. A container for containing a translucent or transparent liquid and for producing a graphical image appearing at a position within the container, comprising:

a container wall defining an interior of the container for receiving the liquid;  
20 a printed image comprising image data abutting an exterior surface of the container wall; and  
a lenticular lens array comprising an optic rib surface and a transparent lens layer, the lenticular lens array focusing a viewer's line of sight on or about a focusing area corresponding to a portion of the container wall at  
25 which the printed image abuts the exterior surface, wherein the lenticular lens array is integrally formed with the container wall.

24. The container of claim 23, wherein the printed image is an interlaced image and is positioned relative to the exterior surface to register the image data to the optic rib surface.

5 25. The container of claim 23, further including a label with a contact surface on which the printed image is provided and wherein the label is attached to the exterior surface of the container wall with the contact surface abutting the exterior surface.

10 26. The container of claim 23, wherein the lenticular lens array is positioned within a first portion of the container wall separated by a portion of the container interior from a second portion of the container wall abutting the printed image.

27. The container of claim 26, wherein the optic rib surface is substantially contiguous with the exterior surface of the container wall.

15 28. The container of claim 23, further including a light directing element in the container wall adapted for directing received light toward a portion of the container wall abutting the printed image.

29. The container of claim 23, wherein printed image is formed by printing the image onto the exterior surface of the container wall.

20 30. A container adapted for producing a graphical image observable by a viewer external to the container, comprising:

a front container wall comprising a flexible material and including a viewing window fabricated of a material passing light through the window;

a rear container wall comprising the flexible material attached to the front container wall to define an interior of the container;

25 a printed image element positioned on an interior surface of the rear container wall; and



a lenticular lens array positioned over at least a portion of the printed image including a plurality of lenticules facing the interior of the container and focusing on the printed image element.

5 31. A container adapted for producing a graphical image observable by a viewer external to the container, comprising:

a container wall having a front portion and a rear portion defining an interior space for receiving a volume of a liquid;

10 a printed image element comprising graphical data for producing the graphical image positioned on an exterior surface of the container wall on the rear portion; and

a lenticular lens array focusing a line of sight of the viewer on the printed image element positioned in the rear portion of the container wall with a lens layer adjacent the printed image element and a plurality of lenticules facing the interior space.

15 32. The container of claim 31, further including a frontal printed image element comprising a forefront image positioned on an exterior surface of the container wall on the front portion.

20 33. The container of claim 31, wherein the printed image element includes a first and a second interlaced image, the graphical data of the printed image element being configured such that the first interlaced image is included in the graphical image observable by the viewer when the liquid in the container covers the lenticular lens array and the second interlaced image is included in the graphical image observable by the viewer when the liquid in the container does not cover the lenticular lens array.

25 34. The container of claim 31, wherein the graphical data of the printed image element is adapted based on magnification characteristics of the liquid and a distance from the front portion to the rear portion to produce a graphical image on a first predetermined fraction of the front portion of the container wall when the liquid covers the lens array and on a second

predetermined fraction of the front portion of the container wall smaller than the first predetermined fraction when the liquid does not cover the lens array.

35. The container of claim 31, wherein the lenticules extend beyond an interior surface of the container wall into the interior space.

5

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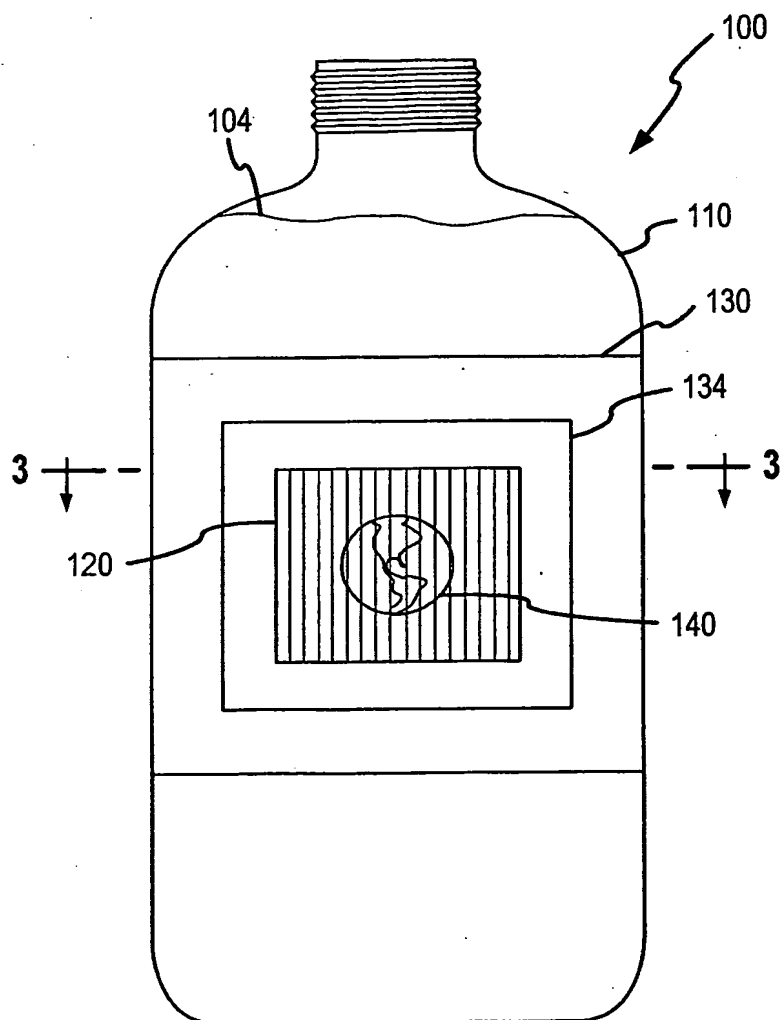


FIG. 1

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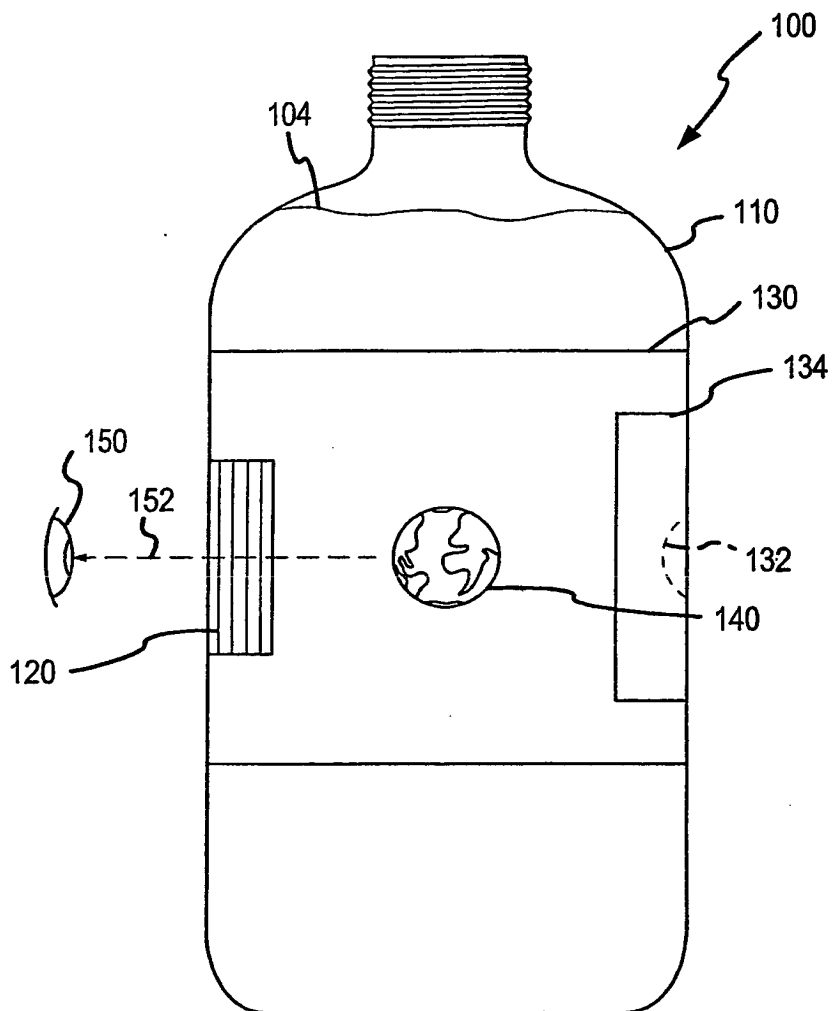


FIG. 2

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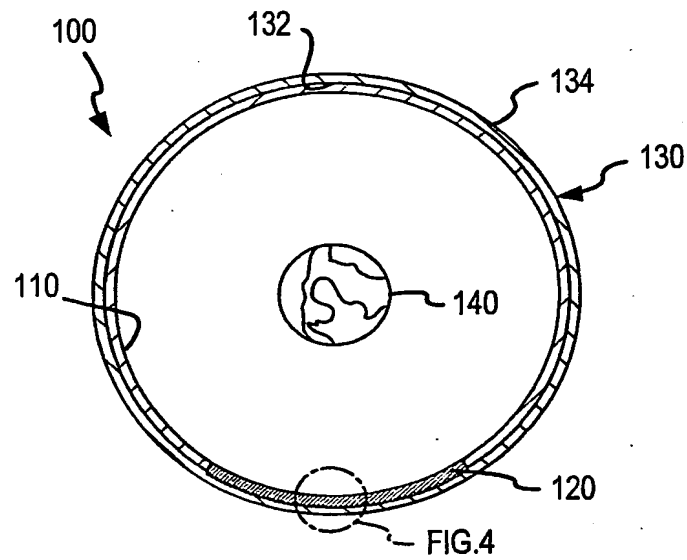


FIG. 3

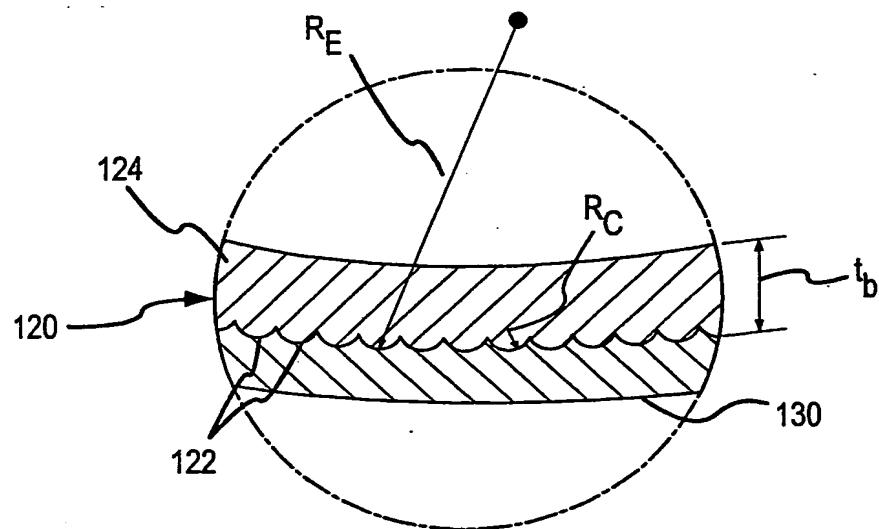


FIG. 4

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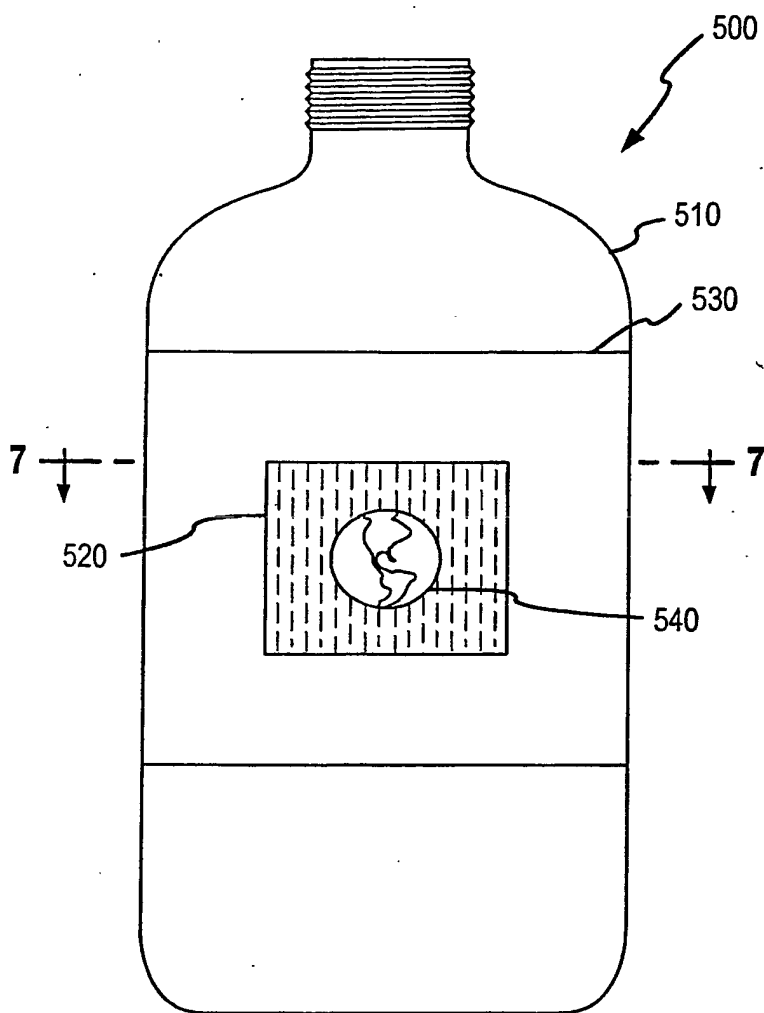


FIG. 5

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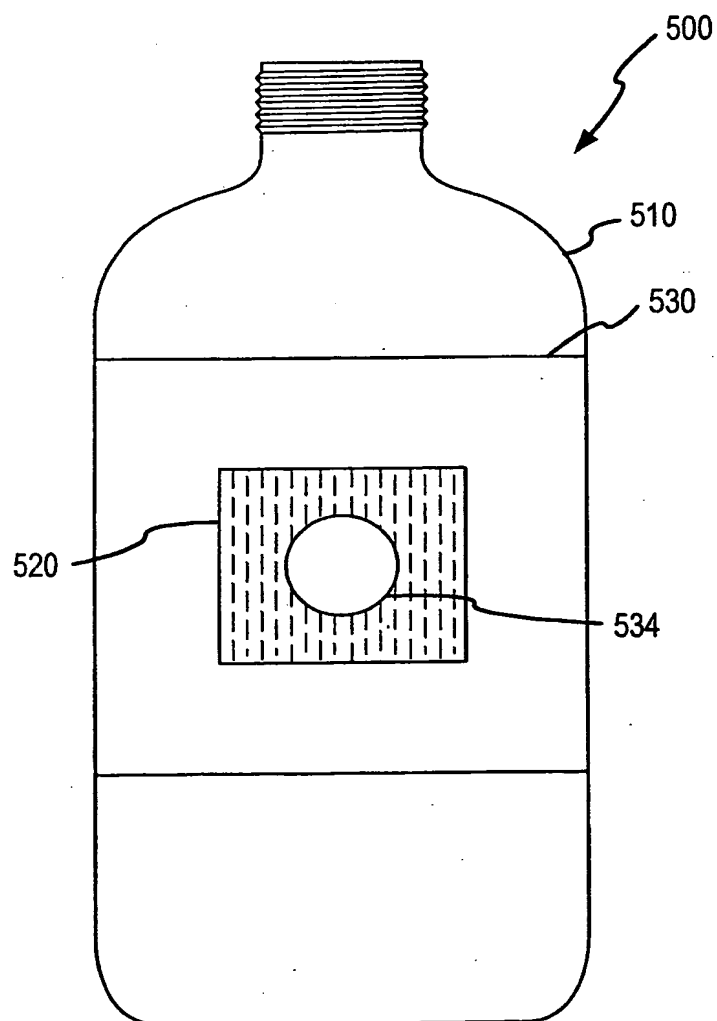


FIG. 6

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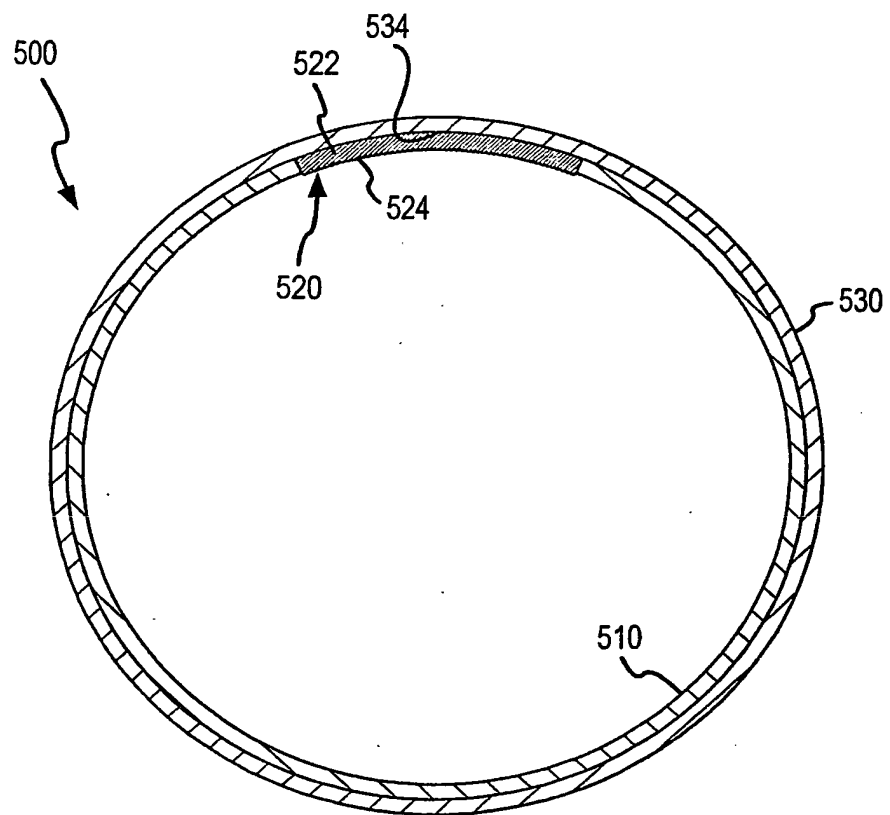


FIG. 7



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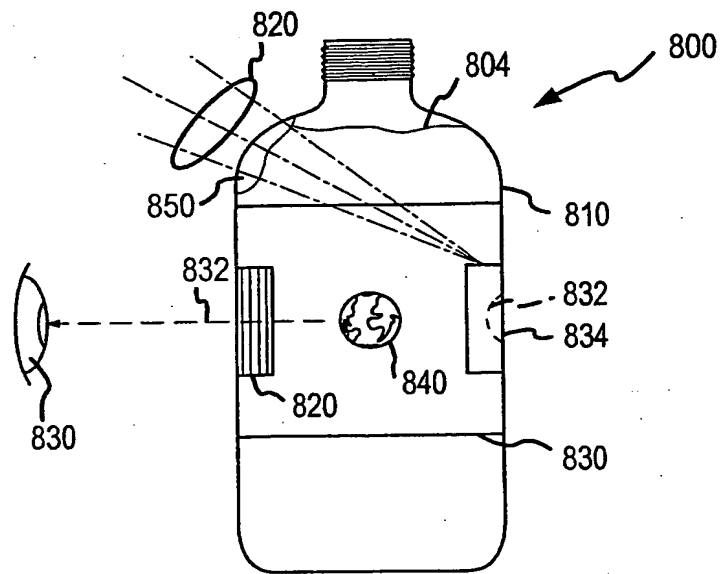


FIG. 8

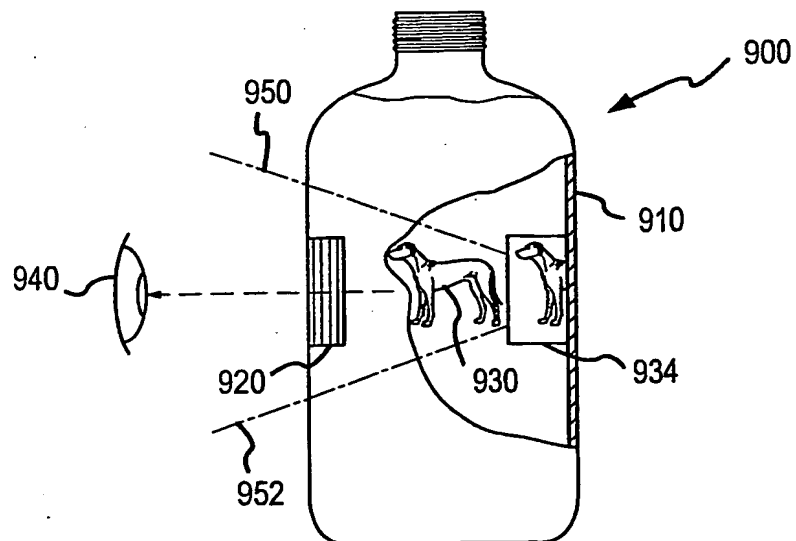


FIG. 9

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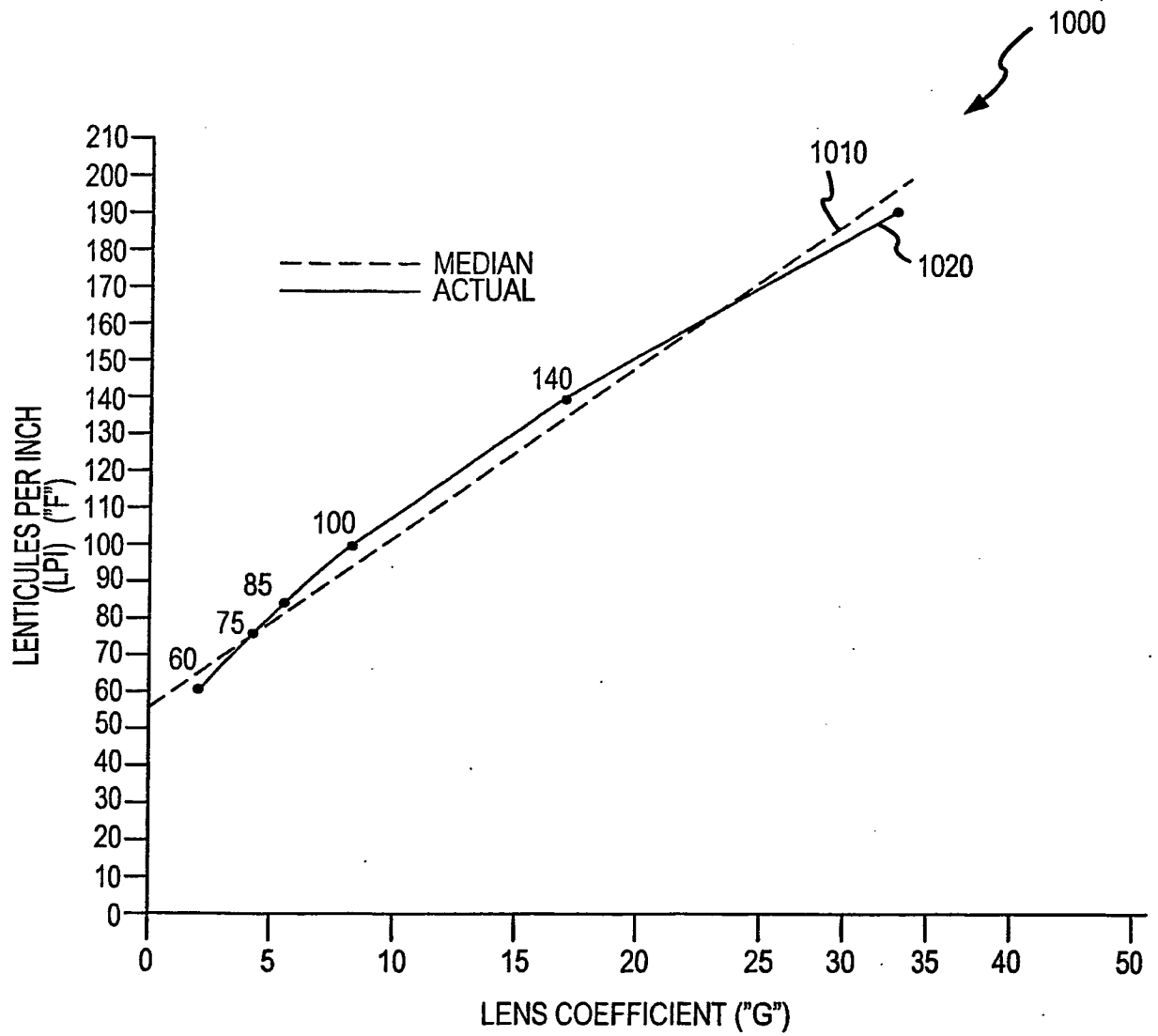


FIG.10

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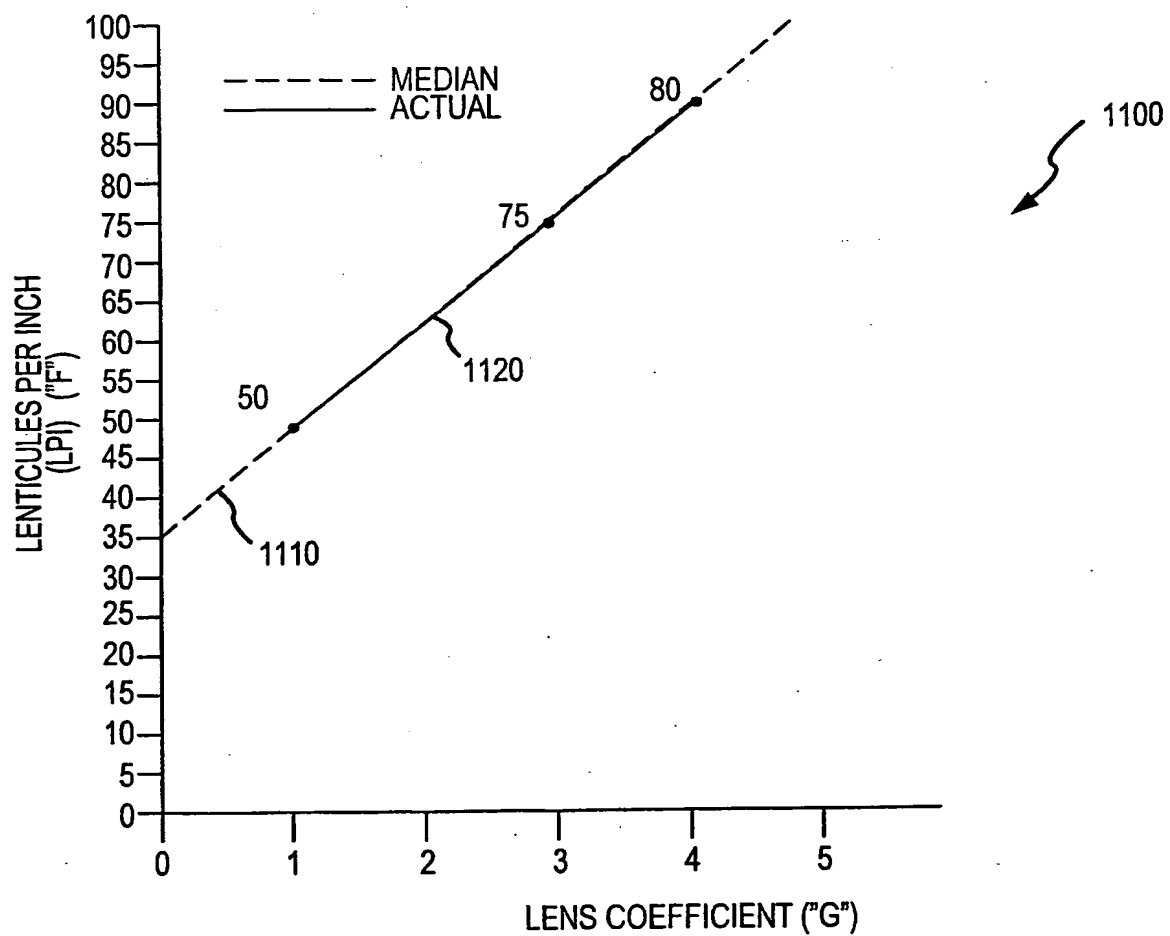


FIG.11

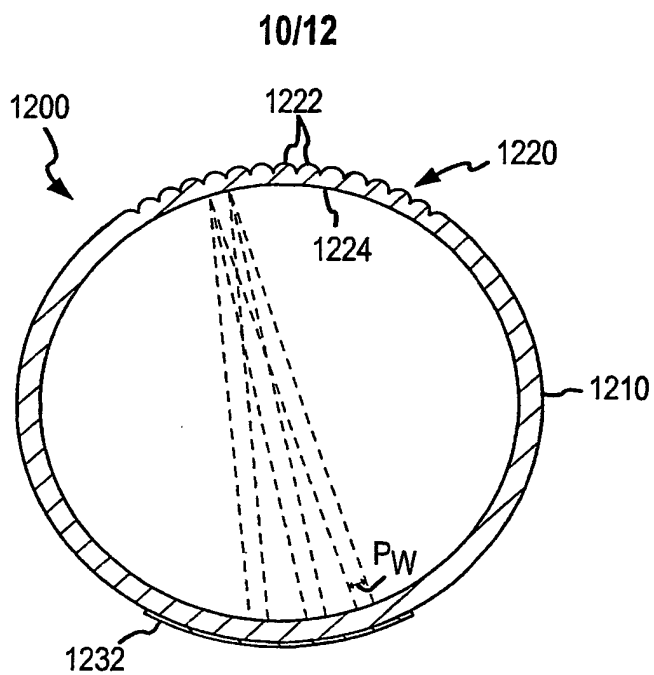


FIG.12

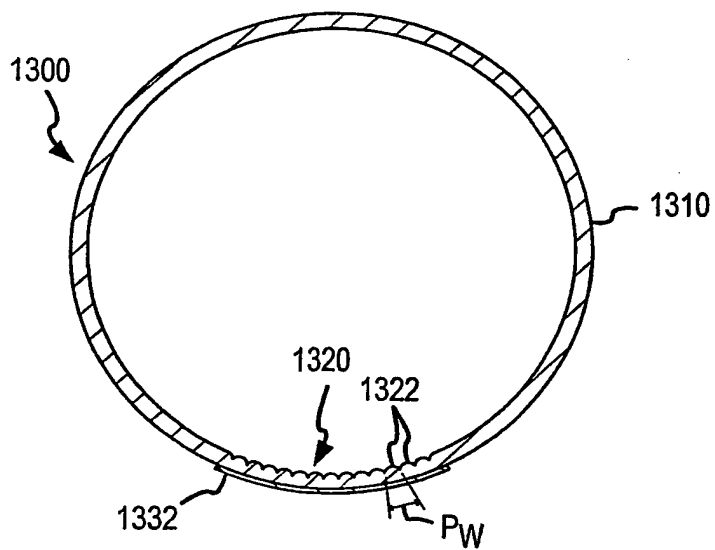


FIG.13

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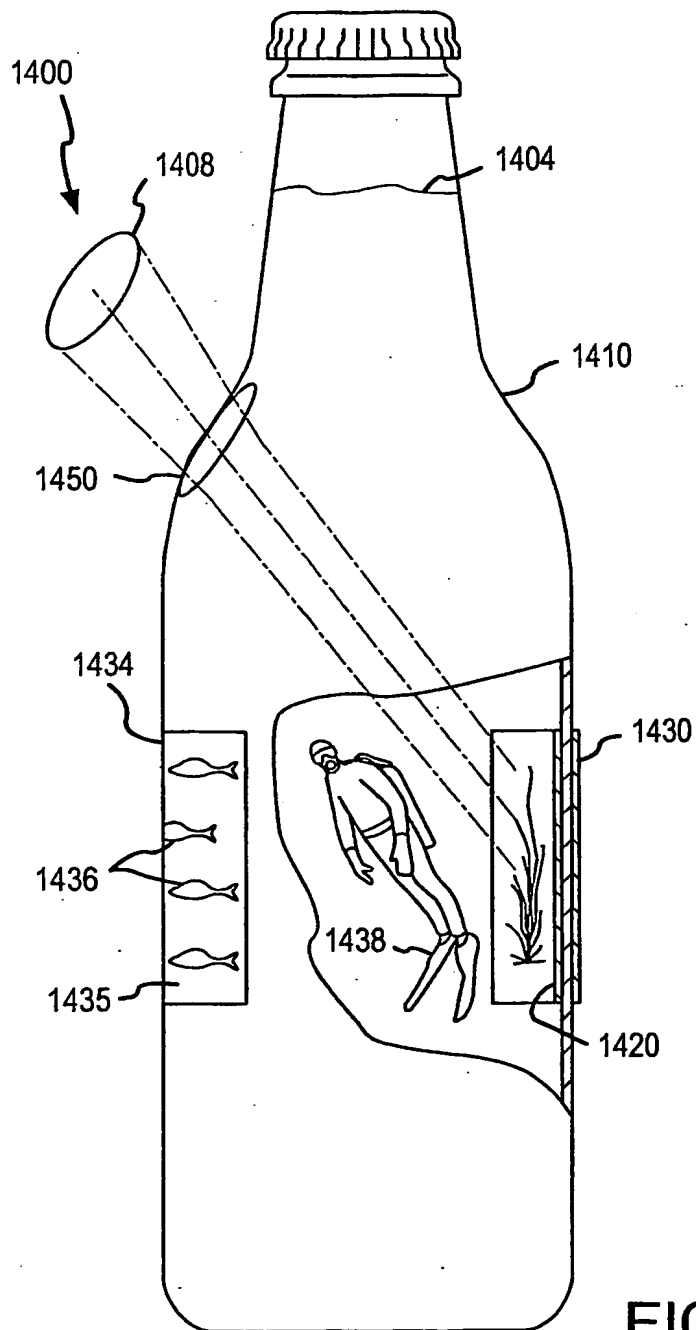


FIG. 14

12/12

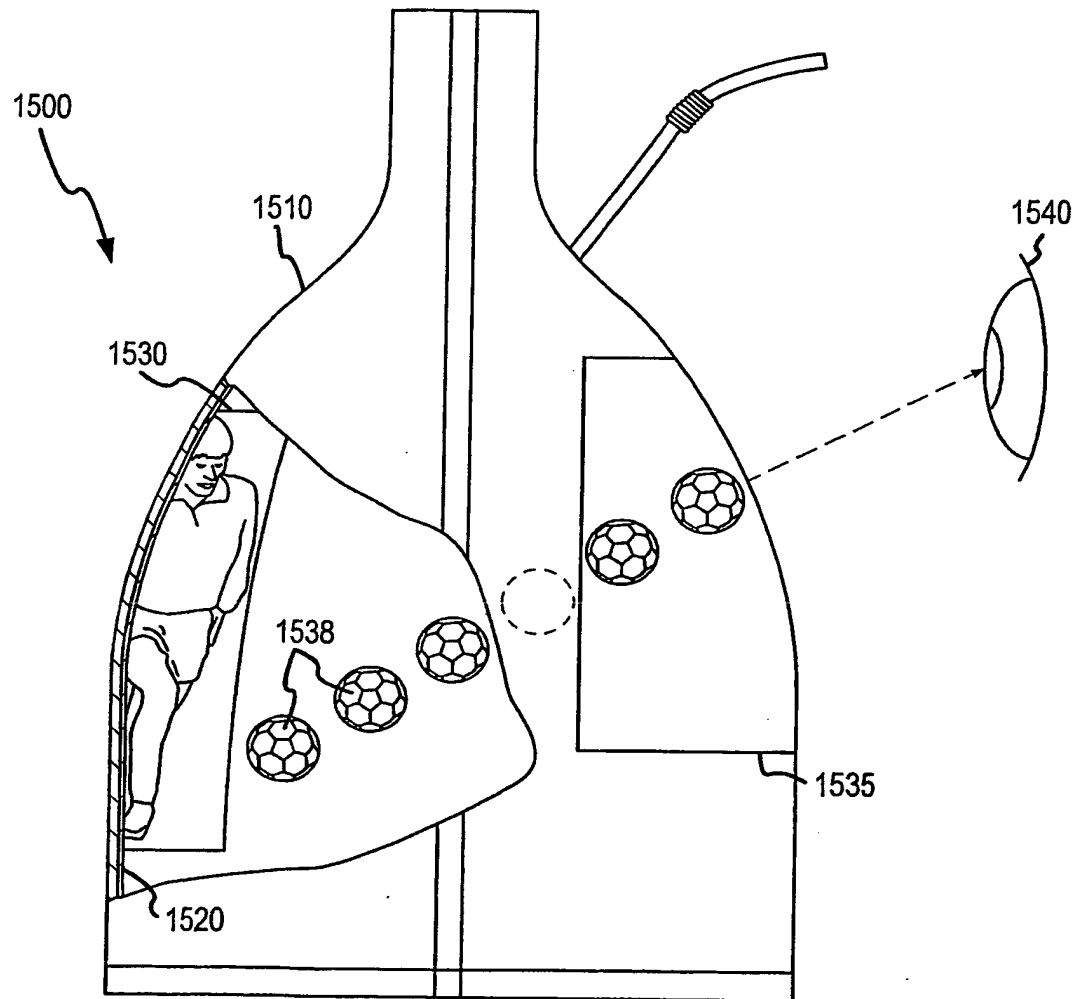


FIG. 15

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/23480

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(7) : G02B 027/10

US CL : 359/619,454-456, 618, 622-623, 742-743, 599, 804; 206/168, 139; 437/365

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 359/619,454-456, 618, 622-623, 742-743, 599, 804; 206/168, 139; 437/365

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
Please See Continuation Sheet**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-049175 A (KICHIRO) 23 February 1999, see entire document.	1,6,10,12-14,23,26-27
X	US 5,676,401 A(WITKOWSKI) 14 October 1997, see entire document.	2,4,5,7,11,15,16,20-22,24 and 29
Y		3,25

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

15 October 2003 (15.10.2003)

Date of mailing of the international search report

27 OCT 2003

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**INTERNATIONAL SEARCH REPORT**

PCT/US03/23480

**Continuation of B. FIELDS SEARCHED Item 3:**

US PAT; US-PGPUB; EPO; JPO; DERWENT; IBM TDB

bottle, container, liquid, leticular, image, array, graphic, picture, can, cup, focus, focal